Safety Factors

As stated in the ARHCO Technical Criteria for the Prevention of Criticality, page I.C-3.5, safety factors must be included in all limits and the three degrees of safety factor specified are based upon the confidence in calculations and the risks involved. A common method of applying safety factors is the use of fractional critical dimensions, volumes or masses. The advantage of using fractional critical dimensions is the ease of application using readily available critical dimension data. While these values are satisfactory in most cases, large systems thus specified may have an effective multiplication constant (k_{eff}) very close to one, the critical condition. In these cases effective protection will not be attained. On the other hand, the fraction of critical dimension method may be overly restrictive for smaller systems.

A safety factor based on the k_{eff} of a system provides a more consistent overall protection. However, this method of applying the safety factor must be used with caution when dealing with small critical systems where small changes in critical dimensions may result in large changes in k_{eff}. Unless the k_{eff} safety factor is less than that normally required for larger systems, the resulting minute dimensional safety factor may be beyond the control of equipment fabricators.

The criticality prevention specialist must consider the limitations on the use of either method in applying safety factors to critical limits. Both k_{eff} limits and dimension limits are specified in the ARHCO criteria, page I.C-6.4.2.

In the following figures the k_{eff} of fractional critical slabs, cylinders, masses and volumes are indicated for both reflected and bare systems using plutonium-water solution densities. These figures are used only to illustrate the variation one can find. Other fissile systems could be more restrictive.

The first part of the calculations for the figure was done with the HFN diffusion theory code at .01, .02, .03, .07, .15, .3, .6, and 1.0 grams of plutonium per cubic centimeter. Although this code is known to be accurate for thermal systems it becomes non-conservative at high concentrations. Therefore, the DTF4 transport theory code was used to obtain k-effective values for the faster systems over a range (including sufficient overlap to permit a smooth curve to be drawn) of .07, .15, .6, 1, 2, 5, 7, 10, 15 and 19.6 grams of plutonium per cubic centimeter. The indicated critical reflected slab thickness for plutonium metal may be somewhat large as a result of poor flux matching between core and reflector. However, for our purposes the indicated change in k-effective should be satisfactory.